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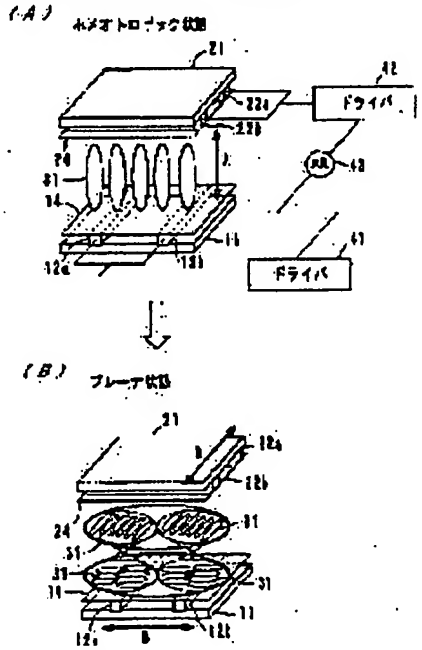
(54) LIQUID CRYSTAL DISPLAY DEVICE AND METHOD FOR DRIVING THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain a liquid crystal display device with which display contrast is heightened by improving reflectance in a planar state and which has excellent response in changing into the planar state, and a method for driving the same.
SOLUTION: The liquid crystal display device is provided with a liquid crystal display element having a liquid crystal exhibiting the cholesteric phase held between substrates 11, 21 and performing display by using selective reflection of the liquid crystal, and drivers 41, 42 to apply an electric field to the liquid crystal with the aid of electrodes 12a, 12b, 22a, 22b disposed on the respective substrates 11, 21. When a longitudinal electric field in the direction of an arrow A is applied between the electrodes 12a, 12b and the electrodes 22a, 22b, the liquid crystal is reset to a homeotropic state in which long axes of the liquid crystal molecules 31 are aligned in the vertical direction. At this stage, on rapidly deleting the longitudinal electric field and simultaneously applying a lateral electric field in the direction of an arrow B between the electrodes 12a and 12b and the electrodes 22a and 22b, the liquid crystal is aligned in a state in which the long axes of the liquid crystal molecules 31 are aligned all together in the direction of the lateral electric field and changes into the planar state with large domains.



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CLAIMS

[Claim(s)]
[Claim 1] The liquid crystal display component which pinches the liquid crystal in which a cholesteric phase is shown, and displays between the substrates of a pair using the selective reflection of this liquid crystal, It has the driving means which impresses electric field to said liquid crystal from the electrode prepared in the substrate of said pair. Said liquid crystal has a forward dielectric constant anisotropy, and said driving means the electric field impressed to said liquid crystal The liquid crystal display characterized by being able to switch to vertical electric field almost perpendicular to a substrate side, and almost level horizontal electric field, and impressing horizontal electric field after impression termination of vertical electric field, and changing liquid crystal to a planar condition.
[Claim 2] The liquid crystal display according to claim 1 characterized by preparing the level orientation film in an interface with the liquid crystal of the substrate of said pair.
[Claim 3] Said level orientation film is a liquid crystal display according to claim 2 characterized by carrying out rubbing processing in the direction of horizontal electric field.
[Claim 4] Said horizontal electric field are claim 1 characterized by being the field strength below the threshold for dispelling torsion of a liquid crystal molecule, and a liquid crystal display according to claim 2 or 3.
[Claim 5] The drive approach which is the drive approach of impressing and driving electric field from the electrode prepared in the substrate of said pair to the liquid crystal in which the cholesteric phase which has the forward dielectric constant anisotropy pinched between the substrates of a pair is shown, and is characterized by to impress almost parallel horizontal electric field to a substrate side after impression termination of vertical electric field almost perpendicular to a substrate side, and to change said liquid crystal to a planar condition.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the liquid crystal display which pinches a liquid crystal display and its drive approach, and the liquid crystal in which a cholesteric phase is shown, and displays between the substrates of a pair especially using the selective reflection in the planar condition of this liquid crystal, and its drive approach.
[0002]
[Description of the Prior Art] Generally, in order that a reflective mold liquid crystal display component may display by reflecting ambient light (external light), compared with the transparency mold liquid crystal display component which needs a back light, it can be displayed by little power consumption and adopted as displays, such as a cellular phone and mobile computing devices. Moreover, in the case of the liquid crystal which has memory nature, in a still picture display, a drive is unnecessary, and a low power is still more possible for it.
[0003] The liquid crystal (represented with the chiral nematic liquid crystal which added chiral material to the nematic liquid crystal) which has a cholesteric phase also in this kind of reflective mold liquid crystal display component displays by switching the orientation of a liquid crystal molecule to a focal conic condition (transparency condition of light), or a planar condition (selective reflection condition of light), and driving as follows. In addition, it explains as a premise that a drive here is a chiral nematic liquid crystal which has a forward dielectric constant anisotropy.
[0004] That is, as shown in drawing 3 (A), a liquid crystal display component consists of a configuration which pinched the chiral nematic liquid crystal between the substrate 11 equipped with Electrodes 12a and 12b, and the substrate 21 equipped with Electrodes 22a and 22b, respectively, and insulator layers 13 and 23 are formed at the electrode forming face of each substrates 11 and 21.
[0005] Liquid crystal will be reset by the HOMEOTORO pick condition that the major axis of the molecule aligned in the direction of electric field, if it is beyond a threshold for the field strength to dispel torsion (spiral structure) of the liquid crystal molecule 31 when the vertical electric field of the direction of arrow-head A are impressed between Electrodes 12a and 12b and Electrodes 22a and 22b. Since this condition does not have memory nature, if vertical electric field are eliminated, the liquid crystal molecule 31 will return to a distorted array.
[0006] In this case, if vertical electric field are eliminated rapidly, as shown in drawing 3 (B), torsion returns, the major axis of a molecule 31 will be in an parallel planar condition to substrates 11 and 21, and liquid crystal will reflect the light of predetermined wavelength. On the other hand, when vertical electric field are eliminated gradually, torsion returned, and there will focal conic be a major axis of a molecule 31 liquid crystal along a field perpendicular to substrates 11 and 21, and it makes light penetrate. In the state of focal conic, black is observed by preparing a light absorption layer in the rear face of a substrate 11, or giving a light absorption function to substrate 11 the very thing.
[0007]
[Problem(s) to be Solved by the Invention] By the way, by said conventional drive approach, if vertical electric field are rapidly eliminated in a HOMEOTORO pick condition in order to change liquid crystal to a planar condition, as for the liquid crystal molecule 31, the major axis will be in an parallel orientation condition to substrates 11 and 21. However, as shown in drawing 3 (B), dispersion is produced in the direction of orientation of the liquid crystal molecule on a flat surface parallel to a substrate side. For this reason, discontinuity arose inside the liquid crystal layer, two or more formation of the field (domain) of the lump arranged on a flat surface parallel to a substrate in the direction where a molecule is the same was carried out, and the interface had arisen between each domain.

[0008] When a domain is small and many domain interfaces existed at this time, light will be scattered about by interface reflection and had the trouble that invited decline in the reflection factor in the angle-of-visibility direction of selective reflection wavelength, and the contrast of a display fell. Moreover, there was room of an improvement also in the response at the time of vertical electric field being eliminated rapidly and liquid crystal changing from a HOMEOTORO pick condition to a planar condition.
[0009] Then, the purpose of this invention is to offer the good liquid crystal display and its drive approach of a response at the time of being able to raise the reflection factor in a planar condition, and being able to raise the contrast of a display, and changing to a planar condition.
[0010]
[The configuration, an operation, and effectiveness] of invention In order to attain the above purpose, the liquid crystal display concerning this invention The liquid crystal display component which pinches the liquid crystal in which a cholesteric phase is shown, and displays between the substrates of a pair using the selective reflection of this liquid crystal, It has the driving means which gives electric field to said liquid crystal from the electrode prepared in the substrate of said pair. Said liquid crystal has a forward dielectric constant anisotropy, and said driving means the electric field impressed to said liquid crystal It is characterized by being able to switch to vertical electric field almost perpendicular to a substrate side, and almost level horizontal electric field, and impressing horizontal electric field after impression termination of vertical electric field, and changing liquid crystal to a planar condition.
[0011] Moreover, the drive approach concerning this invention is the drive approach of impressing and driving electric field from the electrode prepared in the substrate of said pair to the liquid crystal in which the cholesteric phase which has the forward dielectric constant anisotropy pinched between the substrates of a pair is shown, and it is characterized by to impress almost parallel horizontal electric field to a substrate side after impression termination of vertical electric field almost perpendicular to a substrate side, and to change said liquid crystal to a planar condition.
[0012] In the liquid crystal display concerning this invention, and its drive approach, in case liquid crystal is made into a HOMEOTORO pick condition, vertical electric field are eliminated from this condition and liquid crystal is changed to a planar condition by impressing vertical electric field to the liquid crystal in which a cholesteric phase is shown, horizontal electric field are impressed. By impression of horizontal electric field, the major axis of a molecule with a large dielectric constant set-comes to be easy of the liquid crystal which has a forward dielectric constant anisotropy in the direction of horizontal electric field, the discontinuity in a liquid crystal layer decreases, and the domain which is the same massive array area becomes large. Now, a domain interface decreases, dispersion by interface reflection of light decreases, and a reflection factor improves. Consequently, the contrast of a display will improve. Based on impression of such horizontal electric field, the response by which a liquid crystal molecule changes from an almost perpendicular condition to coincidence to a substrate side at an almost parallel condition will also improve. As for said horizontal electric field, it is desirable to set it as the field strength below the threshold for dispelling torsion of a liquid crystal molecule.
[0013] In the liquid crystal display concerning this invention, it is desirable to prepare the level orientation film in an interface with the liquid crystal of the substrate of a pair. In case liquid crystal changes with level orientation film to a planar condition, the major axis of a molecule becomes easy to change to an almost parallel condition to a substrate side.
[0014] Furthermore, it is desirable to perform rubbing processing to said level orientation film in the direction of horizontal electric field. If such rubbing processing is performed, it will become easier to arrange the orientation of the liquid crystal molecule which is in contact with the orientation film in the direction of horizontal electric field, and a stacking tendency will improve.
[0015]
[Embodiment of the Invention] Hereafter, the operation gestalt of the liquid crystal display concerning this invention and its drive approach is explained with reference to an accompanying drawing.
[0016] (Refer to the 1st operation gestalt and drawing 1) The outline configuration of the liquid

crystal display which is the 1st operation gestalt of this invention is shown in drawing 1 . This liquid crystal display has the same configuration as fundamentally as the conventional liquid crystal display shown in drawing 3 , and the same sign as drawing 3 is given to the same member. That is, Electrodes 12a and 12b and Electrodes 22a and 22b are formed in the opposed face of the bottom substrate 11 which consists of glass, a resin film, etc., and the upper substrate 21, respectively, and the level orientation film 14 and 24 is further formed on it. In addition, an insulator layer may be formed like the conventional example and the level orientation film 14 and 24 may be formed on it. Although it is desirable that more than one are prepared in 1 pixel as for Electrodes 12a, 12b, 22a, and 22b, depending on pixel size or the magnitude of electric field to impress, you may arrange only in the pixel boundary section.

[0017] The liquid crystal in which a cholesteric phase is shown is pinched among substrates 11 and 21. As liquid crystal in which a cholesteric phase is shown, it is the chiral nematic liquid crystal which added the chiral material of sufficient amount to show a cholesteric phase in a nematic liquid crystal, and what has a forward dielectric constant anisotropy is used, for example.

[0018] That is, the liquid crystal in which a cholesteric phase is shown has the anisotropy from which a refractive index and a dielectric constant differ in the direction (minor axis) where the rod-like liquid crystal molecule 31 is perpendicular to the longitudinal direction (major axis) and it. A dielectric constant anisotropy calls liquid crystal with the larger dielectric constant of the direction of a major axis of a liquid crystal molecule than that of the direction of a minor axis forward liquid crystal. If a dielectric constant anisotropy impresses an electrical potential difference high enough to forward liquid crystal, torsion will be cleared, and it moves so that the major axis of a liquid crystal molecule may be suitable in the direction parallel to the direction of electric field. A threshold exists in the electrical potential difference which this torsion solves.

[0019] By the way, a chiral nematic liquid crystal is obtained by adding the chiral material of the specified quantity to a nematic liquid crystal. Generally as for this chiral nematic liquid crystal, the rod-like liquid crystal molecule shows nothing and a cholesteric phase for the distorted array. When light carried out incidence to this liquid crystal and light carries out incidence from an parallel direction to a helical shaft, selective reflection of the light of the wavelength shown by lambda=np is carried out (planar condition). Here, lambda is the distance (it is hereafter described as a spiral pitch) in which wavelength and n can twist the average refractive index of a liquid crystal molecule, and p has twisted 360 degrees of liquid crystal molecules. On the other hand, when light carries out incidence from a perpendicular direction to a helical shaft, light is penetrated theoretically (focal conic condition). A display is performed using this selective reflection and transparency.

[0020] Electrodes 12a, 12b, 22a, and 22b are connected to drivers 41 and 42, respectively, and the pulse of the predetermined amplitude supplied from a power source 43 and an electrical-potential-difference value is impressed. If it drives so that an electrical-potential-difference difference may be produced between Electrodes 12a and 12b and Electrodes 22a and 22b, the vertical electric field of the direction perpendicular to a substrate side of arrow-head A will arise. Moreover, if it drives so that an electrical-potential-difference difference may be produced among Electrodes 12a and 12b and among Electrodes 22a and 22b, the horizontal electric field of the direction level to a substrate side of arrow-head B will arise.

[0021] If it is in a **** 1 operation gestalt, as shown in drawing 1 (A), the molecule 31 resets liquid crystal in the HOMEOTORO pick condition which aligned in the direction of electric field by impressing the vertical electric field of the direction of arrow-head A first with the field strength beyond the threshold for dispelling torsion of the liquid crystal molecule 31 between Electrodes 12a and 12b and Electrodes 22a and 22b.

[0022] Next, the liquid crystal of each pixel is alternatively changed to a planar condition or a focal conic condition. While eliminating said vertical electric field rapidly to the pixel which chooses a planar condition, as shown in drawing 1 (B), the horizontal electric field of the direction of arrow-head B are impressed with the field strength below the threshold for dispelling torsion among Electrodes 12a and 12b and among Electrodes 22a and 22b.

[0023] By said vertical electric field being eliminated, the liquid crystal molecule 31 reset by the

HOMEOTORO pick condition tends to shift to an orientation condition parallel to a substrate side, i.e., a planar condition, so that it may get used to an interface with substrates 11 and 21. horizontal electric field are impressed at this time — the major axis of the liquid crystal molecule 31 near the interface with substrates 11 and 21 — the direction of horizontal electric field (the direction of arrow-head B) — a set — being easy — as shown in drawing 1 (B), in a planar condition, a domain becomes large.

[0024] Thus, if a domain becomes large, a domain interface will decrease, dispersion by interface reflection of light will decrease, the reflection factor in the angle-of-visibility direction of selective reflection wavelength will improve, and the contrast of a display will improve. Moreover, the response by which the major axis of the liquid crystal molecule 31 changes with impression of horizontal electric field from a perpendicular condition to a level condition to a substrate side also improves. Furthermore, a liquid crystal molecule becomes easy to change to an parallel condition by forming the level orientation film 14 and 24 to a substrate side.

[0025] On the other hand, vertical electric field are eliminated gradually, without impressing horizontal electric field to the pixel which chooses a focal conic condition. In order to eliminate vertical electric field gradually, the amplitude level of an electrical potential difference can be reduced gradually, or the duty ratio of a pulse voltage can be changed and the approach of decreasing electrical-potential-difference impression time amount gradually can be adopted.

[0026] (Refer to the 2nd operation gestalt and drawing 2) The outline configuration of the liquid crystal display which is the 2nd operation gestalt of this invention is shown in drawing 2 . This liquid crystal display has the same configuration as the 1st operation gestalt shown in drawing 1 , and differing is in the point of having performed rubbing processing to the interface with the liquid crystal of the level orientation film 14 and 24 in the direction of arrow-head B' which is a direction parallel to the horizontal electric field of the direction of arrow-head B. In addition, the same sign as the same member as drawing 1 is given to drawing 2 .

[0027] The drive approach of liquid crystal is as said 1st operation gestalt having explained, and if it is in this 2nd operation gestalt, since rubbing processing is performed to parallel with the direction of horizontal electric field at the level orientation film 14 and 24, in case liquid crystal is changed to a planar condition, its stacking tendency of the liquid crystal molecule 31 improves further.

[0028] (Other operation gestalten) in addition, the liquid crystal display concerning this invention and its drive approach are not limited to said each operation gestalt, within the limits of the summary, can be boiled variously and can be changed.

[0029] It can constitute from what was constituted from one layer of the display device shown with said each operation gestalt especially as a display device, a thing (full color display) which carried out the laminating of the display device which performs each selective reflection of R, G, and B to three layers, or a thing which carried out the laminating of the display device which performs selective reflection of the wavelength of arbitration to two-layer.

[0030] Moreover, although the liquid crystal display component of a passive-matrix mold is mentioned as the example with said operation gestalt, also in the liquid crystal display component of the active-matrix mold which has a switching element (for example, TFT:Thin Film Transistor and TFD:Thin Film Diode) for every pixel, this invention is applicable.

[0031] Furthermore, although prepare the same electrode also as a vertical substrate with said operation gestalt, he is trying to generate horizontal electric field, respectively and effectiveness is the most remarkable, effectiveness is acquired even if it prepares a solid electrode in one substrate. The number of an electrode may be changed with a vertical substrate.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The perspective view showing the outline configuration of the liquid crystal display which is the 1st operation gestalt shows the case where (A) has liquid crystal in a HOMEOTORO pick condition, and (B) shows with it the case where liquid crystal changes to a planar condition.
[Drawing 2] The perspective view showing the outline configuration of the liquid crystal display which is the 2nd operation gestalt shows the case where a liquid crystal molecule changes to a planar condition.
[Drawing 3] The perspective view showing the outline configuration of the conventional liquid crystal display shows the case where (A) has liquid crystal in a HOMEOTORO pick condition, and (B) shows with it the case where liquid crystal changes to a planar condition.
[Description of Notations]
11 21 -- Substrate
12a, 12b, 22a, 22b -- Electrode
14 24 -- Level orientation film
31 -- Liquid crystal molecule
41 42 -- Driver
43 -- Power source

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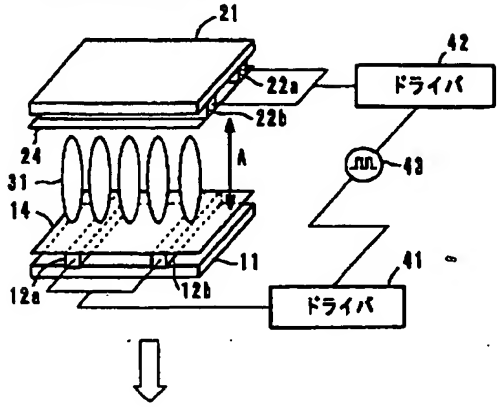
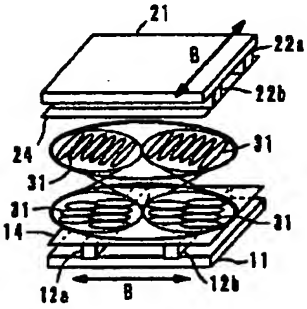
DRAWINGS

[Drawing 1]

(A) ホメオトロピック状態

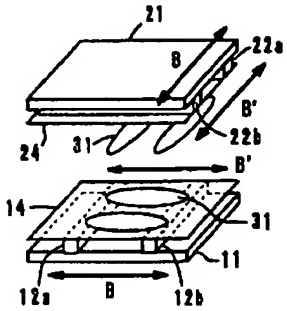


(B) プレーナ状態



[Drawing 2]

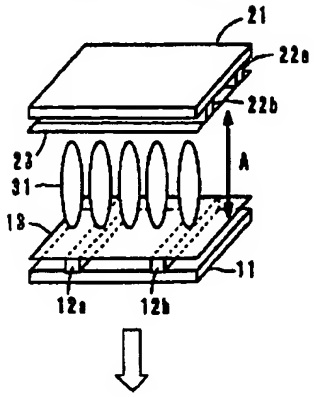
プレーナ状態



[Drawing 3]

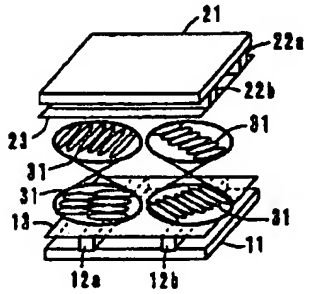
(A)

ホメオトロピック状態



(B)

プレーナ状態



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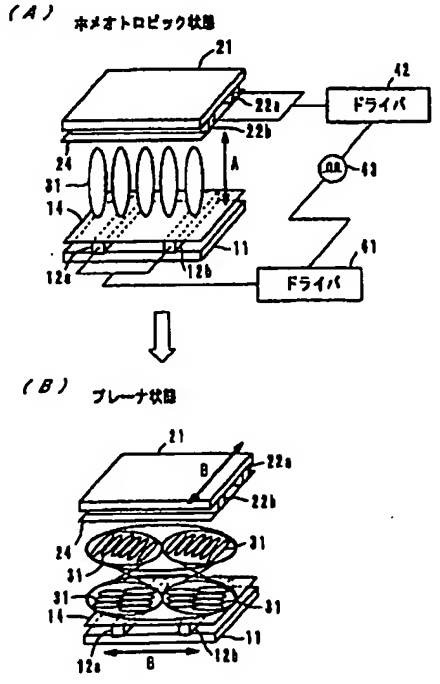
(54)【発明の名称】　液晶表示装置及びその駆動方法

(57)【要約】
【課題】　ブレーナ状態での反射率を向上させて表示のコントラストを高めることができ、また、ブレーナ状態へ変化する際のレスポンスの良好な液晶表示装置及びその駆動方法を得る。
【解決手段】　基板１１，２１間にコレステリック相を示す液晶を挟持し、該液晶の選択反射を利用して表示を行う液晶表示素子と、各基板１１，２１に設けた電極１２ａ，１２ｂ，２２ａ，２２ｂから液晶に電界を印加するドライバ４１，４２を備えた液晶表示装置。電極１２ａ，１２ｂと電極２２ａ，２２ｂとの間に矢印Ａ方向の縦電界を印加すると、液晶はその分子３１の長軸が垂直方向に整列したホメオトロピック状態にリセットされる。ここで、縦電界を急激に消去すると共に電極１２ａ，１２ｂの間及び電極２２ａ，２２ｂの間に矢印Ｂ方向の横電界を印加すると、液晶はその分子３１の長軸が横電界方向に揃って配向され、ドメインの大きなブレーナ状態に変化する。



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【特許請求の範囲】

【請求項１】　一対の基板間にコレステリック相を示す液晶を挟持し、該液晶の選択反射を利用して表示を行う液晶表示素子と、前記一対の基板に設けた電極から前記液晶に電界を印加する駆動手段とを備え、
前記液晶は正の誘電率異方性を有するものであり、
前記駆動手段は前記液晶に印加する電界を、基板面にほぼ垂直な縦電界及びほぼ水平な横電界に切り換え可能であり、かつ、縦電界の印加終了後に横電界を印加して液晶をプレーナ状態に変化させること、
を特徴とする液晶表示装置。

【請求項２】　前記一対の基板の液晶との界面に水平配向膜を設けたことを特徴とする請求項１記載の液晶表示装置。

【請求項３】　前記水平配向膜は横電界方向にラビング処理されていることを特徴とする請求項２記載の液晶表示装置。

【請求項４】　前記横電界は液晶分子のねじれを解くための閾値以下の電界強度であることを特徴とする請求項１、請求項２又は請求項３記載の液晶表示装置。

【請求項５】　一対の基板間に挟持された正の誘電率異方性を有するコレステリック相を示す液晶に対して、前記一対の基板に設けた電極から電界を印加して駆動する駆動方法であって、
基板面にほぼ垂直な縦電界の印加終了後に基板面にほぼ平行な横電界を印加して前記液晶をプレーナ状態に変化させること、
を特徴とする駆動方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、液晶表示装置及びその駆動方法、特に、一対の基板間にコレステリック相を示す液晶を挟持し、該液晶のプレーナ状態における選択反射を利用して表示を行う液晶表示装置及びその駆動方法に関する。

【０００２】

【従来技術】一般に、反射型液晶表示素子は、環境光（外部の光）を反射することにより表示を行うため、バックライトを必要とする透過型液晶表示素子に比べて、少ない消費電力で表示が可能であり、携帯電話やモバイル機器などの表示部に採用されている。また、メモリ性を有する液晶の場合は静止画表示においては駆動が不要でさらに低消費電力が可能である。

【０００３】この種の反射型液晶表示素子の中でもコレステリック相を有する液晶（ネマチック液晶にカイラル材を添加したカイラルネマチック液晶によって代表される）は、液晶分子の配向をフォーカルコニック状態（光の透過状態）とプレーナ状態（光の選択反射状態）のいずれかに切り換えて以下のように駆動して表示を行う。なお、ここでの駆動は正の誘電率異方性を有するカイラルネマチック液晶であることを前提として説明する。

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【０００４】即ち、図３（Ａ）に示すように、液晶表示素子はそれぞれ電極１２ａ，１２ｂを備えた基板１１と電極２２ａ，２２ｂを備えた基板２１との間にカイラルネマチック液晶を挟持した構成からなり、各基板１１，２１の電極形成面には絶縁膜１３，２３が設けられている。

【０００５】電極１２ａ，１２ｂと電極２２ａ，２２ｂとの間に矢印Ａ方向の縦電界を印加すると、その電界の強さが液晶分子３１のねじれ（螺旋構造）を解くための閾値以上であれば、液晶はその分子の長軸が電界方向に整列したホメオトロピック状態にリセットされる。この状態はメモリ性がないため、縦電界を消去すると、液晶分子３１はねじれた配列に戻る。

【０００６】この場合、縦電界を急激に消去すると、図３（Ｂ）に示すように、液晶はねじれが戻って分子３１の長軸が基板１１，２１に対して平行なプレーナ状態になり、所定波長の光を反射する。一方、縦電界を徐々に消去すると、液晶はねじれが戻って分子３１の長軸が基板１１，２１と垂直な面に沿ったフォーカルコニック状態になり、光を透過させる。基板１１の裏面に光吸収層を設けるか、基板１１自体に光吸収機能を付与することで、フォーカルコニック状態では黒色が観察される。

【０００７】

【発明が解決しようとする課題】ところで、前記従来の駆動方法では、液晶をプレーナ状態に変化させるために、ホメオトロピック状態において縦電界を急激に消去すると、液晶分子３１はその長軸が基板１１，２１に対して平行な配向状態となる。しかし、図３（Ｂ）に示すように、基板面に平行な平面上における液晶分子の配向方向にはばらつきを生じる。このため、液晶層内部に不連続部が生じ、基板に平行な平面上で分子が同じ方向に配列している一塊の領域（ドメイン）が複数形成され、各ドメイン間に界面が生じていた。

【０００８】このとき、ドメインが小さく多くのドメイン界面が存在すると、光は界面反射によって散乱することになり、選択反射波長の視野角方向での反射率の低下を招来して表示のコントラストが低下するという問題点を有していた。また、縦電界が急激に消去され液晶がホメオトロピック状態からプレーナ状態へ変化する際のレスポンスにも改善の余地があった。

【０００９】そこで、本発明の目的は、プレーナ状態での反射率を向上させて表示のコントラストを高めることができ、また、プレーナ状態へ変化する際のレスポンスの良好な液晶表示装置及びその駆動方法を提供することにある。

【００１０】

【発明の構成、作用及び効果】以上の目的を達成するため、本発明に係る液晶表示装置は、一対の基板間にコレステリック相を示す液晶を挟持し、該液晶の選択反射を

利用して表示を行う液晶表示素子と、前記一対の基板に設けた電極から前記液晶に電界を付与する駆動手段とを備え、前記液晶は正の誘電率異方性を有するものであり、前記駆動手段は前記液晶に印加する電界を、基板面にほぼ垂直な縦電界及びほぼ水平な横電界に切り換え可能であり、かつ、縦電界の印加終了後に横電界を印加して液晶をプレーナ状態に変化させることを特徴とする。

【００１１】また、本発明に係る駆動方法は一対の基板間に挟持された正の誘電率異方性を有するコレステリック相を示す液晶に対して、前記一対の基板に設けた電極から電界を印加して駆動する駆動方法であって、基板面にほぼ垂直な縦電界の印加終了後に基板面にほぼ平行な横電界を印加して前記液晶をプレーナ状態に変化させることを特徴とする。

【００１２】本発明に係る液晶表示装置及びその駆動方法においては、コレステリック相を示す液晶に対して縦電界を印加することにより液晶をホメオトロピック状態とし、この状態から縦電界を消去して液晶をプレーナ状態に変化させる際に横電界を印加する。横電界の印加によって、正の誘電率異方性を有する液晶は誘電率の大きい分子の長軸が横電界の方向に揃いやすくなり、液晶層内の不連続部が減少して塊状の同一配列領域であるドメインが大きくなる。これにて、ドメイン界面が少なくなり、光の界面反射による散乱が減少し、反射率が向上する。その結果、表示のコントラストが向上することになる。このような横電界の印加に基づいて、同時に、液晶分子が基板面に対してほぼ垂直な状態からほぼ平行な状態に変化するレスポンスも向上することになる。前記横電界は液晶分子のねじれを解くための閾値以下の電界強度に設定することが好ましい。

【００１３】本発明に係る液晶表示装置においては、一対の基板の液晶との界面に水平配向膜を設けることが好ましい。水平配向膜によって液晶がプレーナ状態に変化する際に分子の長軸が基板面に対してほぼ平行な状態に変化しやすくなる。

【００１４】さらに、前記水平配向膜には横電界方向にラビング処理を施すことが好ましい。このようなラビング処理が施されていると、配向膜に接している液晶分子の配向をより横電界方向に揃えやすくなり、配向性が向上する。

【００１５】

【発明の実施の形態】以下、本発明に係る液晶表示装置及びその駆動方法の実施形態について、添付図面を参照して説明する。

【００１６】（第１実施形態、図１参照）図１に本発明の第１実施形態である液晶表示装置の概略構成を示す。この液晶表示装置は図３に示した従来の液晶表示装置と基本的には同様の構成を有しており、同じ部材には図３と同じ符号が付されている。即ち、ガラスや樹脂フィルム等からなる下基板１１及び上基板２１の対向面にそれぞれ電極１２ａ，１２ｂ及び電極２２ａ，２２ｂが形成され、さらにその上に水平配向膜１４，２４が形成されている。なお、従来例と同様に絶縁膜を形成し、その上に水平配向膜１４，２４を形成してもよい。電極１２ａ，１２ｂ，２２ａ，２２ｂは１画素内に複数設けられていることが好ましいが、画素サイズや印加する電界の大きさによっては画素境界部のみに配置してもよい。

【００１７】コレステリック相を示す液晶は基板１１，２１の間に挟持されている。コレステリック相を示す液晶としては、例えば、ネマチック液晶にコレステリック相を示すのに十分な量のカイラル材を添加したカイラルネマチック液晶であって、正の誘電率異方性を有するものが使用される。

【００１８】即ち、コレステリック相を示す液晶は、棒状の液晶分子３１が、その長手方向（長軸）とそれに垂直な方向（短軸）で屈折率や誘電率が異なる異方性を有している。液晶分子の長軸方向の誘電率が短軸方向のそれよりも大きい液晶を誘電率異方性が正の液晶と称する。誘電率異方性が正の液晶に十分に高い電圧を印加するとねじれが解け、液晶分子の長軸が電界方向と平行な方向に向くように動く。このねじれが解ける電圧には閾値が存在する。

【００１９】ところで、カイラルネマチック液晶はネマチック液晶に所定量のカイラル材を添加することによって得られる。このカイラルネマチック液晶は、一般的に、棒状の液晶分子がねじれた配列をなし、コレステリック相を示している。この液晶に光が入射すると、ヘリカル軸に対して平行な方向から光が入射した場合、λ＝ｎｐで示される波長の光を選択反射する（プレーナ状態）。ここで、λは波長、ｎは液晶分子の平均屈折率、ｐは液晶分子が３６０°ねじれている距離（以下、螺旋ピッチと記す）である。一方、ヘリカル軸に対して垂直な方向から光が入射した場合、原理的に光は透過される（フォーカルコニック状態）。この選択反射及び透過を利用して表示が行われる。

【００２０】電極１２ａ，１２ｂ，２２ａ，２２ｂはそれぞれドライバ４１，４２に接続され、電源４３から供給される所定の振幅、電圧値のパルスが印加される。電極１２ａ，１２ｂと電極２２ａ，２２ｂとの間に電圧差を生じるように駆動すると、基板面に垂直な矢印Ａ方向の縦電界が生じる。また、電極１２ａ，１２ｂの間及び電極２２ａ，２２ｂの間に電圧差を生じるように駆動すると、基板面に水平な矢印Ｂ方向の横電界が生じる。

【００２１】本第１実施形態にあっては、図１（Ａ）に示すように、まず、電極１２ａ，１２ｂと電極２２ａ，２２ｂとの間に矢印Ａ方向の縦電界を、液晶分子３１のねじれを解くための閾値以上の電界強度で印加することにより、液晶をその分子３１が電界方向に整列したホメオトロピック状態にリセットする。

【００２２】次に、各画素の液晶をプレーナ状態又はフ

ォーカルコニック状態に選択的に変化させる。プレーナ状態を選択する画素に対しては、前記縦電界を急激に消去すると共に、図１（Ｂ）に示すように、電極１２ａ，１２ｂの間及び電極２２ａ、２２ｂの間に矢印Ｂ方向の横電界をねじれを解くための閾値以下の電界強度で印加する。

【００２３】ホメオトロピック状態にリセットされている液晶分子３１は前記縦電界が消去されることで、基板１１，２１との界面に馴染むように基板面に平行な配向状態、即ち、プレーナ状態に移行しようとする。このとき、横電界が印加されることによって、基板１１，２１との界面近傍の液晶分子３１の長軸が横電界方向（矢印Ｂ方向）に揃いやすくなり、図１（Ｂ）に示すように、プレーナ状態においてドメインが大きくなる。

【００２４】このように、ドメインが大きくなると、ドメイン界面が少なくなって光の界面反射による散乱が減少し、選択反射波長の視野角方向での反射率が向上し、表示のコントラストが向上する。また、横電界の印加によって、液晶分子３１の長軸が基板面に対して垂直な状態から水平な状態に変化するレスポンスも向上する。さらに、水平配向膜１４，２４が設けられていることによって、液晶分子が基板面に対して平行な状態に変化しやすくなる。

【００２５】一方、フォーカルコニック状態を選択する画素に対しては、横電界を印加することなく、縦電界を徐々に消去する。縦電界を徐々に消去するには、電圧の振幅レベルを徐々に低下させたり、パルス電圧のデューティー比を変化させて電圧印加時間を徐々に減少させる等の方法を採用することができる。

【００２６】（第２実施形態、図２参照）図２に本発明の第２実施形態である液晶表示装置の概略構成を示す。この液晶表示装置は図１に示した第１実施形態と同様の構成を有しており、異なるのは、水平配向膜１４，２４の液晶との界面に、矢印Ｂ方向の横電界と平行な方向である矢印Ｂ’方向にラビング処理を施した点にある。なお、図２には図１と同じ部材に同じ符号が付されている。

【００２７】液晶の駆動方法は前記第１実施形態で説明したとおりであり、この第２実施形態にあっては、水平配向膜１４，２４に横電界方向と平行にラビング処理が施されているため、液晶をプレーナ状態に変化させる際に液晶分子３１の配向性がさらに向上する。

【００２８】（他の実施形態）なお、本発明に係る液晶表示装置及びその駆動方法は前記各実施形態に限定するものではなく、その要旨の範囲内で種々に変更することができる。

【００２９】特に、表示素子としては、前記各実施形態で示した表示素子の１層で構成したもの、Ｒ，Ｇ，Ｂの各選択反射を行う表示素子を３層に積層したもの（フルカラー表示）、あるいは任意の波長の選択反射を行う表示素子を２層に積層したものなどで構成することができる。

【００３０】また、前記実施形態では単純マトリクス型の液晶表示素子を例に挙げているが、画素ごとにスイッチング素子（例えば、ＴＦＴ：Thin Film Transistor や、ＴＦＤ：Thin Film Diode）を有するアクティブマトリクス型の液晶表示素子においても本発明を適用できる。

【００３１】さらに、前記実施形態では上下基板とも同様の電極を設けてそれぞれ横電界を発生させるようにしており効果が最も顕著であるが、一方の基板にはベタ電極を設けても効果は得られる。上下基板で電極の本数を異ならせてもよい。

【図面の簡単な説明】

【図１】第１実施形態である液晶表示装置の概略構成を示す斜視図で、（Ａ）は液晶がホメオトロピック状態にある場合を示し、（Ｂ）は液晶がプレーナ状態に変化した場合を示す。

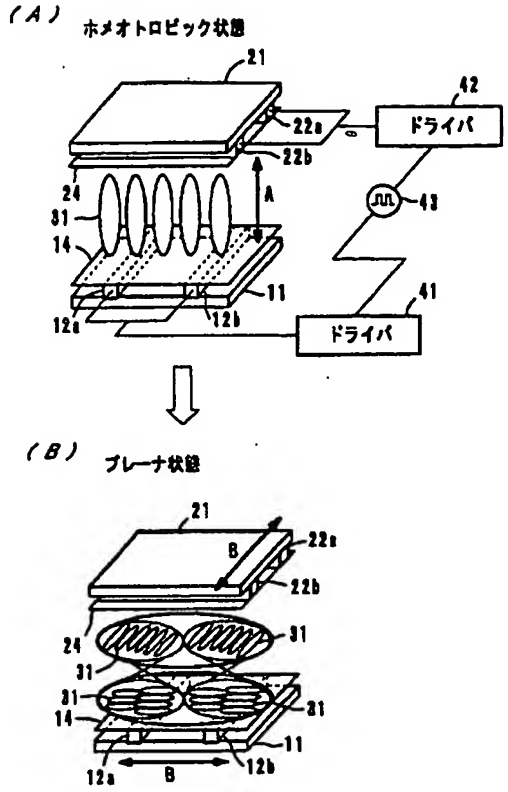
【図２】第２実施形態である液晶表示装置の概略構成を示す斜視図で、液晶分子がプレーナ状態に変化した場合を示す。

【図３】従来の液晶表示装置の概略構成を示す斜視図で、（Ａ）は液晶がホメオトロピック状態にある場合を示し、（Ｂ）は液晶がプレーナ状態に変化した場合を示す。

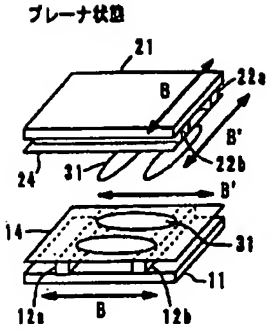
【符号の説明】

１１，２１…基板
１２ａ，１２ｂ，２２ａ，２２ｂ…電極
１４，２４…水平配向膜
３１…液晶分子
４１，４２…ドライバ
４３…電源

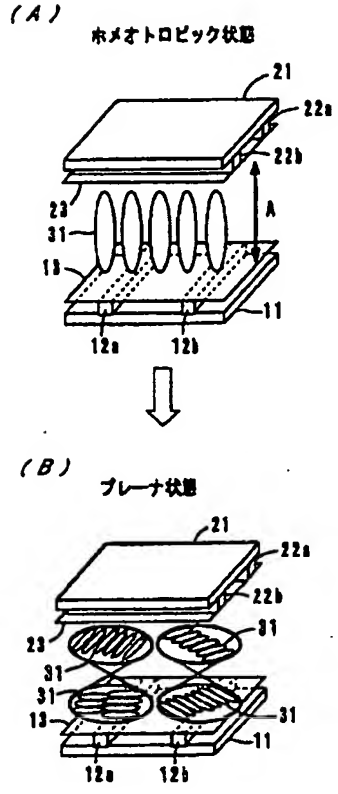
【図１】



【図２】



【図３】



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